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PEA DISEASES AND THEIR CONTROL

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PEAS ARE SUBJECT to a number of diseases, several of which may cause serious injury and loss. It is the purpose of this bulletin to describe these diseases briefly, so that they may be identified by the grower, and to give recommendations for preventing and controlling them.

Ascochyta blight is seed-borne. Seed grown in the Northwestern States is practically free from the disease germ and should be obtained for planting if available. Refuse left in the field after the crop is harvested should be plowed under and the peas rotated with other crops.

Bacterial blight is a seed-borne disease, and the same methods of control as for *Ascochyta* blight should be practiced.

The wilt organisms are seed-borne to a slight extent. They live almost indefinitely in the soil, so that crop rotation is of no great value. The only control of the disease consists in the use of resistant varieties, a number of which are now available.

Root rots are caused by a group of several organisms that live a long time in the soil. They cannot be entirely controlled. The losses may be reduced by planting on well-drained soil, by careful preparation of the soil, by maintaining a continuous growth, by the use of the proper fertilizer, and by a judicious crop rotation.

Root knot is caused by a parasitic eelworm that inhabits the sandy soils of the Southern States and California. It causes swellings and galls on the roots of many crops. Some of the cowpeas, grasses, and cereals are resistant and should be used in the rotation. Many weeds are susceptible and should be destroyed by clean cultivation.

Powdery mildew produces a white, talclike powdery growth on the leaves and other parts of the plant. When control measures are necessary, dust with sulphur. The first application should be made when the disease first appears. Several applications may be necessary to hold the disease in check.

Septoria blight, anthracnose, and downy mildew are three diseases that do not occur commonly. They rarely require the application of control measures, and none are recommended. Seed grown in the Northwestern States is more nearly free from seed-borne diseases than that grown in the East and should be used for planting when available.

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PEA DISEASES AND THEIR CONTROL

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THE PEA INDUSTRY

PEAS are an important food in the diet of a large percentage of the population of the United States. They are grown to some extent in practically every part of the country, either for home use, for market, for canning, or for seed purposes. A much greater number of growers raise peas for home use than for any other purpose. The total acreage so grown is, on the whole, small, since only a small quantity, or enough to supply the family needs, is grown in each garden.

The growers engaged in the commercial pea industry may be divided into four groups: (1) The market gardeners or truck farmers, who grow peas for consumption as a green vegetable; (2) those who grow peas for canning; (3) the seed growers; and (4) farmers who produce dry field peas. The growing of green peas for market is carried on by a large number of farmers along the Atlantic seaboard, the Pacific coast, and to a considerable extent throughout the Central States and in some of the Intermountain States of the West. The culture and shipment of green peas are so widely distributed that peas are now available over much of the country during almost the entire year. The commercial canning of green peas is somewhat localized and represents an important part of the industry in several States, as, for example, Wisconsin, Maryland, and New York. A large number of farmers grow peas for the canners. The seed-growing phase of the industry is highly specialized and is centered chiefly in Washington, Idaho, Montana, and California, and to a less extent in Wisconsin and Michigan. The production of seed is largely in the hands of a comparatively small number of commercial concerns, although a considerable number of farmers are engaged in the growing of the seed for them. Dry field peas are produced in the above-mentioned States and to some extent in Colorado. Many of the field peas are used for splitting for soup, for animal feeding, and as seed for forage, green manure, and cover crops. There is considerable overlapping between seed- and field-pea production, since if a crop grown for seed is not sold for seed purposes it may be sold as dry field peas (fig. 1).

LOSSES FROM DISEASES

The annual losses to the pea crop from diseases can scarcely be estimated (fig. 2). They vary from year to year, depending in many

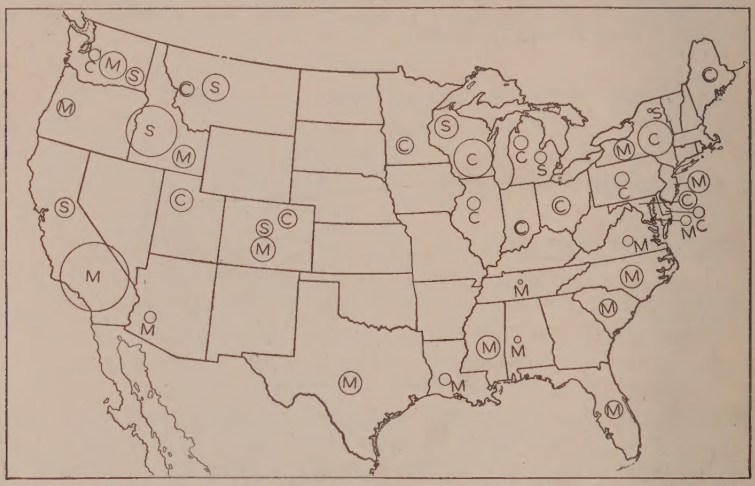

FIGURE 1.—Principal areas of commercial pea production in the United States. *M* indicates peas grown for market; *C*, for canning; and *S*, for seed. The area of the circles roughly indicates the relative size of the industry in each State.

cases on local weather conditions. There may be considerable loss one year and little or none the next. If the soil is wet from excessive

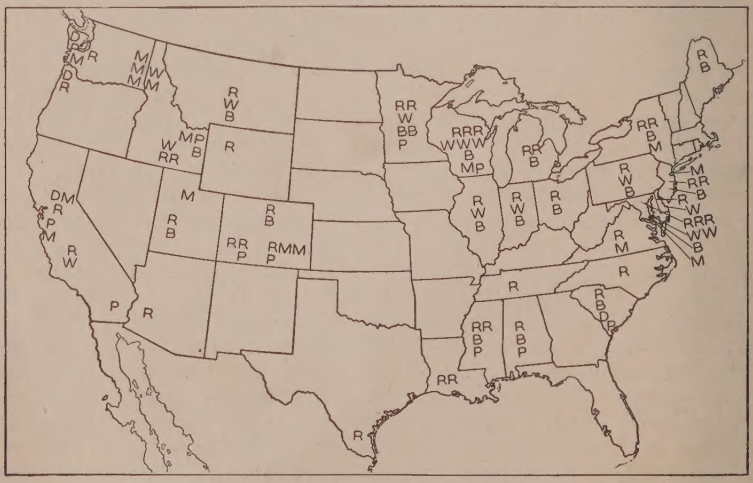

FIGURE 2.—Regions where pea diseases are prevalent. *W*, *Fusarium* wilt; *R*, root rot; *B*, bacterial blight; *M*, mosaic; *P*, powdery mildew; *D*, downy mildew. Single letter denotes mild infection; double letter medium infection; and triple letter, severe infection.

rains and the weather is cool, heavy losses may be expected from root rots and from such diseases as the *Ascochyta* blight and the bacterial blight. If the soil is badly infested, total loss may result from disease.

This bulletin contains descriptions of the various pea diseases, information as to their causes, and recommendations for their prevention and control. Unfortunately, in some cases no control measures are known.

HOW THE VARIOUS DISEASES ARE DISSEMINATED

The fungi and bacteria causing diseases of peas may be carried from one place or plant to another by various means, such as insects, infected seed, drainage water, refuse and stable manure, farm animals and implements, and wind.

INSECTS

There is no way to determine to what extent insects carry disease germs from one plant to another, but it may be considerable in some cases. Insects, such as plant lice, thrips, and leaf hoppers, are common inhabitants of plants and migrate from one to another with considerable frequency. Wounds made by insects feeding on the plant offer favorable places for infection to take place. Insects visiting the lesions caused by fungi and bacteria may carry the germs on their bodies and deposit them on noninfected plants and perhaps in the wounds made by the insects, and in this way, if conditions are favorable, start new infection centers.

INFECTED SEED

Some of the worst plant diseases are carried by the seed. Since this is particularly true of certain diseases of the pea, it is important that disease-free seed be used whenever possible. In most cases, if clean seed is planted, a crop can be grown without very much loss from those diseases that are commonly seed-borne. On the other hand, if infected seed is sown, heavy losses may be expected if weather conditions are favorable to the development of the disease-producing organisms. Seed grown in the intermountain section of the West and along the Pacific coast is more likely to be free from seed-borne diseases than that grown in the regions east of the Rocky Mountains. For that reason, it is advisable to use seed grown in that section of the West whenever possible.

In order to economize in the purchase of seed, farmers sometimes save seed from their own crop. This is a practice not generally recommended and is probably not an economical one. Seed growing is an industry requiring particular knowledge of the type and quality of the varieties grown and special care in maintaining the purity and trueness to type of the stock. The seed-growing companies employ individuals with expert knowledge of these matters whose responsibility is to improve and to maintain the high quality of the seed stock. They are therefore better equipped to supply high-class disease-free seed than anyone unskilled in the seed business. The purchase of disease-free seed from reputable firms is to be recommended.

DRAINAGE WATER

Surface drainage water running from one field to another may be the means of spreading germs, and in some cases explains the outbreak of a disease in fields where the crop has never been grown before. If the crop is planted on high ground, the germs left in the soil may be carried by the water to low-lying fields. With the hope of avoiding

disease by crop rotation, a low-lying field may be selected for the new crop only to find the disease on it as bad as on the abandoned one.

REFUSE AND STABLE MANURE

The pea vines are disposed of in different ways after the peas are shelled, depending to a considerable extent on local conditions and farm needs. In some localities the straw is returned to the soil after the peas are hulled. In other localities it is stacked and used as feed and bedding for livestock, while in still others, the vines are made into silage to be later fed to livestock. If the vines are diseased and are returned directly to the land, the causal organisms serve as a probable source of infection to the succeeding crop of peas. Just what happens to the disease germs on vines put into the silo is not definitely known. The probabilities are that they are destroyed, and, if such is the case, the vines made into silage will not be a source of infection to succeeding crops. On the other hand, returning those vines to the field either in the form of hulled vines or mixed with stable manure would be a means of disseminating the germs to all parts of the farm where this mixture was scattered.

In irrigated regions of the West where peas are grown on a commercial scale, the threshed vines are sometimes used to dam irrigation ditches in order to divert the flow of water into other ditches or to the fields. This is one of the worst possible practices, since if there are any disease-producing organisms on the vines, they will be carried by the water to all parts of the fields.

FARM ANIMALS AND IMPLEMENTS

Farm animals are potential agencies in the distribution of disease germs from one field to another. A certain amount of movement of livestock from one field to another may be unavoidable in the course of farm operations, but as little of it should be allowed as possible when there has been serious loss from diseases. Horses, cattle, or other livestock grazing in a diseased field or feeding on the refuse after the crop is harvested are likely to scatter the disease organisms. Farm implements may likewise be a means of transporting the germs from one place to another, although no great distribution need be expected from that means. Reasonable care should be taken so that infested soil will not be transported from one field to another by roaming animals or by farm machinery. The threshing machine, when used to thresh the crops of different farmers, may carry disease-producing germs from one farm to another. A thorough cleaning of the thresher before it is moved to a new field will eliminate much of this danger.

WIND

The wind may be an important factor in the dissemination of certain pea diseases. In localities where strong winds are prevalent, dry weather common, and the soil light, the disease spores may be carried long distances. The refuse from a previous diseased crop may also be blown considerable distances when strong winds occur.

FARM PRACTICES IN RELATION TO DISEASE CONTROL

Several methods whereby the various diseases of peas may be disseminated from one field to another or from one locality to another have been mentioned. It should be the purpose of the grower to

prevent as much as possible the distribution of destructive diseases on his farm by taking several precautionary measures, the more important of which are discussed in the following paragraphs.

DISINFECTION OF SEED

Inasmuch as some of the worst plant diseases are seed-borne, disinfection of the seed is often of considerable value. However, it destroys only the germs on the surface; those beneath the seed coat cannot be reached without injuring the seed itself. Disinfection of pea seed is of questionable value, but it will do no harm and might be a safe precaution. Experimental data have indicated that treatment of the seed with some of the phenol mercury compounds increases the stand under some conditions, probably because of the protection against decay by soil-borne organisms and the destruction of the disease germs on the surface of the seed. Until more is known about pea-seed treatment, the practice is not generally recommended.

CROP ROTATION

Crop rotation is a good practice even if it is not necessary as a disease-control measure. The germs of several of the pea diseases live in the soil for 2 or 3 years on the debris of previous crops, and others persist almost indefinitely. If peas are repeatedly cropped on the same soil, the disease germs continue to multiply year after year. The lack of information as to the length of time required to starve out all the different organisms attacking peas makes it impossible to make specific recommendations. However, a rotation including peas not oftener than once in 3 years should be practiced. Where farm operations and practices will permit, a longer rotation is desirable. The life of some of the disease germs is shortened if they are buried deep in the soil. In view of that fact, the refuse remaining on the field and the vines returned to it after threshing or hulling should be plowed under as soon after harvest as possible. The use of resistant varieties is about the only way to control those diseases caused by organisms that persist almost indefinitely in the soil and are slightly or not at all influenced by crop rotation and deep plowing. No vetch should be grown in a pea rotation, since the two crops are attacked by some of the same diseases.

DISEASES

ASCOCHYTA BLIGHT

DESCRIPTION

Ascochyta blight is characterized in part by the formation of black to purplish streaks on the stem. The lesions are more conspicuous at the nodes, and enlarge into brown or purplish irregularly shaped areas scattered indiscriminately from the roots to 10 inches or more up the stem.

The leaves may show characteristic symptoms (fig. 3) of the disease in various ways. The spots may be very small, purplish, and very irregular in shape and size, or they may be fairly large and more or less circular. The size and number of the spots and the amount of damage caused depend somewhat on the age of the plants and weather conditions. Under favorable conditions the entire leaf of very suscep-

tible varieties may be so badly injured that it shrivels and dries up. Concentric circles sometimes form in the spots on the leaves.

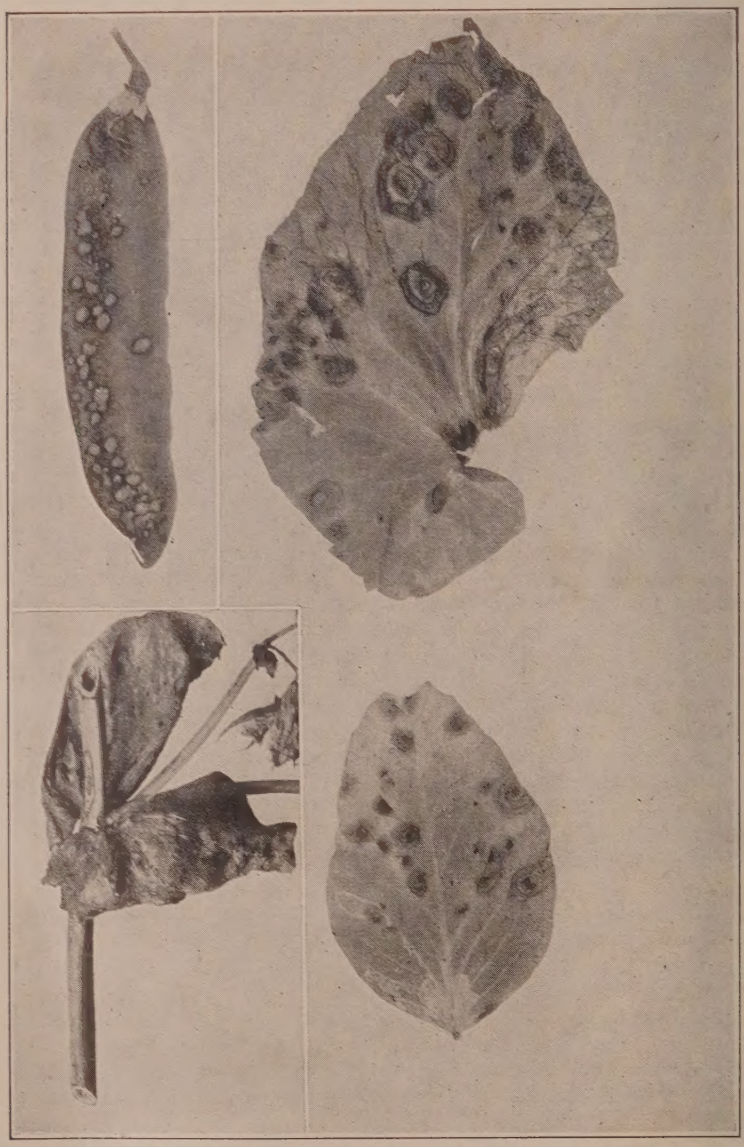

FIGURE 3.—*Ascochyta* blight on the pods, stems, and leaves. Small dark fruiting bodies about the size of a pin point occur in the more or less circular spots. The spores are enclosed in these receptacles, and, on escaping, may fall on other plants and serve as sources of new infections.

The symptoms on the pods (fig. 3) are similar to those on the leaves, except that on the pods the spots are sunken and there are no concentric rings. The causal organism frequently grows through the pods

and penetrates the seeds which serve as sources of infection if such seeds are used to plant the next year's crop. A few small, black or almost black, slightly raised, pimplelike protuberances, about the size of a pin point, may be found scattered in the lesions of the stems, leaves, and pods. The spores or seed bodies of the causal fungus are produced in these little pimples.

CAUSE

The *Ascochyta* blight is caused by any of three different parasites—*Ascochyta pisi* Lib., *Mycosphaerella pinodes* (Berk. and Blox.) Stone, and *Ascochyta pinodella* Jones. Although the symptoms caused by the three fungi may differ somewhat, they have so many characteristics in common that it seems desirable to treat the diseases as one rather than to differentiate them by fine points of distinction. *Ascochyta* blight may occur in all States east of the Mississippi River, but it is rarely, if ever, found in the semiarid seed-producing regions of the Northwest. It may cause heavy losses during seasons of abundant rainfall. The causal organisms are carried by the seed and infect the seedling when it is emerging. Rains following germination splash the spores to surrounding plants, and eventually all the plants in a field may become infected.

CONTROL

The fungus causing *Ascochyta* blight is seed-borne and may also live from one season to the next on the refuse in the field. New infections may start from the use of infected seed and from the refuse left in the field. These facts suggest the importance of using only clean seed and of destroying the refuse in the field. It is not possible to destroy all the refuse in the field, but considerable benefit may be obtained by plowing it under deep as soon as the crop is harvested. Clean or practically disease-free seed is grown in the semiarid regions of the Northwest and should be purchased and used whenever possible. Probably all stocks of seed grown east of the Mississippi River carry the fungus; therefore, it is recommended that western-grown seed be used. At least a 3-year crop rotation should be practiced, and diseased pea vines should not be scattered on land to be used for the next year's crop.

Seed treatment is not recommended. No varieties of peas have been found that are entirely immune to *Ascochyta* blight, although some are less susceptible than others and may be tried if they are suitable to local needs. Some of the less-susceptible varieties are: Short Admiral, Badger Special, Champion of England, Horal, Horsford, Perfection, and Advancer. Complete control of *Ascochyta* blight is probably not possible until definitely resistant varieties have been developed by breeding and selection.

BACTERIAL BLIGHT

DESCRIPTION

The bacterial blight of peas is found on all parts of the plant above the ground. If the infection starts from the seed or if the plants are 3 or more inches high, the vine may be killed without producing a crop. Infection established later may reduce the yield considerably,

the extent of the injury depending largely on weather conditions, Bacterial blight causes water-soaked lesions on the pods (fig. 4, *A*).

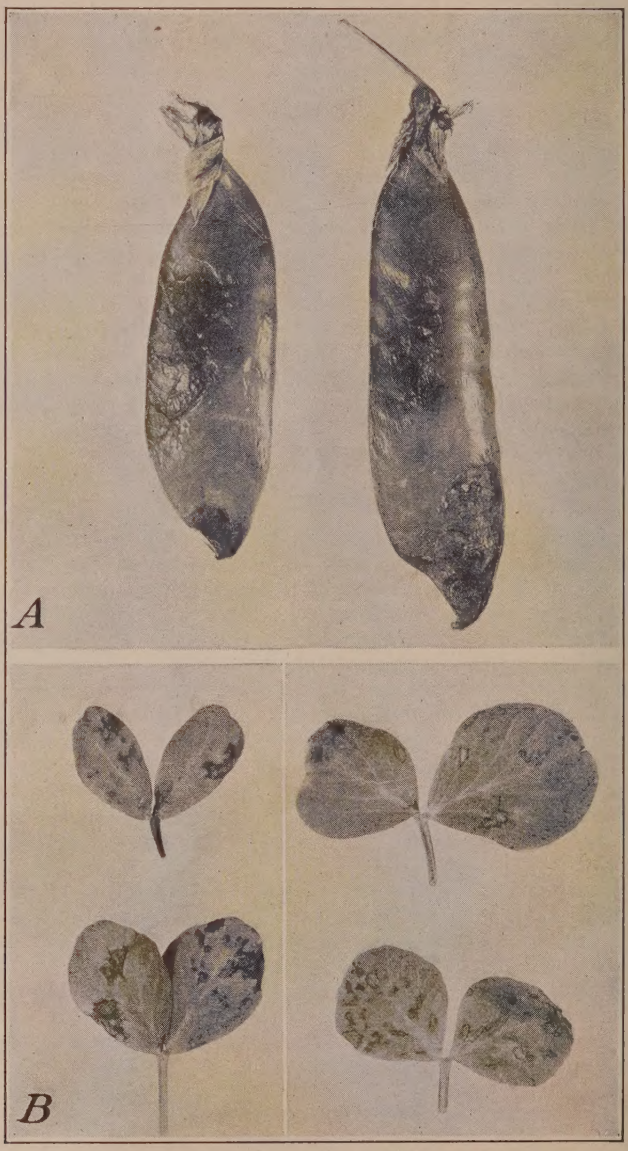

FIGURE 4.—*A*, Bacterial blight on the pods, showing water-soaked, irregularly shaped, slightly sunken spots. The seed may be invaded by the parasite and serve as a source of infection for the new crop. Such seed should not be planted. *B*, Bacterial blight on the leaves. These spots start as small water-soaked areas which gradually kill part of the leaf. Sometimes the injury is so extensive that the plant dies.

stems, leaves (fig. 4, *B*), and stipules. These lesions enlarge under humid conditions, sometimes forming spots of considerable size. A

white to cream-colored slimy ooze may also collect on the surface of the lesions. On the other hand, if the weather turns dry, the infection may dry up. The infected tissue of the leaves and stipules eventually turns brown and papery in texture. Extensive infection of the pods reduces considerably their market value because of their unsightly appearance. There is the danger also that the germs will grow through the pods and infect the seed, which would be a source of infection if the seed was used to plant a new crop.

Bacterial blight has been reported from many States from the Pacific to the Atlantic coasts. The extent of the loss from the disease is not known, but it has been estimated to amount to as much as 25 to 30 percent or more in some fields. It is most severe under conditions of high humidity.

The organism causing bacterial blight of peas is said to produce a similar disease of cowpeas, sweet peas, everlasting peas, and the hyacinth-bean.

CAUSE

Bacterial blight is caused by a parasite (*Bacterium pisi* Sack.) that lives over the winter in the seed but probably not on the refuse left in the field from harvesting. If the germs do not survive the winters in the field, the seed is practically the only source of infection.

CONTROL

No effective control measures are known. Clean seed, if available, offers the best possibility of avoiding infection. Although the disease has been reported from several Western States, there are a few localities in which peas are grown under dry-land conditions where the disease does not occur. A large quantity of pea seed is now being grown under dry-land conditions in what is known as the Palouse area, comprising parts of eastern Washington and northern Idaho. The grower of peas for canning and market-garden purposes should request the seedsmen to supply seed free from the bacterial blight. At any rate, there are good reasons to believe that seed grown in the Western States will be safer to plant and freer from infection than seed grown in the Eastern States. Seedsmen who grow in areas where bacterial blight occurs might profitably alternate infected basic seed stock each year between the dry land and irrigated land, in order to free the seed of the causal organisms.

Seed treatment is not generally recommended, as it is of value only in disinfecting the surface. No permanent control under all conditions can be expected until varieties resistant to the disease have been developed by breeding and selection.

FUSARIUM WILT

DESCRIPTION

When *Fusarium* wilt first makes its appearance in a field, only a few plants show any signs of disease. If susceptible varieties are planted several years in succession on the same field, the infested areas (fig. 5) gradually enlarge and become more numerous and eventually merge with others. Finally, all the soil in the field may be infested.

Attention is first attracted to the wilt disease by the yellowing of the lower leaves and the stunted growth of the plant. A more careful examination shows a definite downward curling of the margins of the leaves (fig. 6). If infection occurs when the plants are fairly small, they may die without producing any peas; on the other hand, if the plants are older when infected, a few pods, poorly filled, may develop. At or near the soil level, the vine is sometimes slightly swollen. Infection takes place from the soil, through the roots, and the causal organism follows the water-conducting canals up the stem, often well into the upper branches, thus hindering the passage of water to the stem and leaves. If the lower part of the stem or the main root is cut open by a sharp knife, the presence of the organism is often indicated by the lemon discoloration it causes to the canals. In some cases, however, no discoloration is produced even though the wilt organism is present. These symptoms must not be confused with the much brighter brick-red discoloration of the water canals caused

FIGURE 5.—*Fusarium* wilt. A portion of a field showing a typical *Fusarium*-wilt infested area.

by a different organism. If wilt-infected plants are pulled several days after injury is apparent, root-rot germs, or other disease-producing germs in the soil, may have damaged the roots to such an extent that it is almost impossible to determine with certainty what organism was responsible for the injury.

CAUSE

Fusarium wilt of peas is caused by a fungous parasite (*Fusarium orthoceras* Appel. and Wr. var. *pisi* Linford) and is very similar to organisms causing wilt in a number of other cultivated plants, among which may be mentioned the tomato, sweetpotato, cotton, cowpea, watermelon, and cabbage.

CONTROL

There is no cure for the pea wilt. As the parasite will live indefinitely in the soil, there is no chance to starve it out by rotation with other crops. Its control can be accomplished only by the growing of

resistant varieties. During recent years the canners and market gardeners, especially the former, have been demanding strains that

FIGURE 6.—*Fusarium* wilt. Note the wilting and drying of the lower leaves and the downward curling of the upper leaves. Later the entire plant becomes yellow and finally dies.

would produce a crop on soil infested with the wilt organism. In response to this demand, some of the State experiment stations and the private seed companies began an intensive study of the problem

and of the needs of the canners and market producers. It was found that in many cases a certain percentage of the plants on badly infested soils resisted the disease. By collecting seed from such plants and growing it on infested soil to eliminate the susceptible plants, it has been possible in the course of a few years to develop strains entirely resistant. Similar results have been accomplished by crossing a susceptible variety with a resistant one and selecting the resistant plants of the desired type from the progeny. By growing the seed each year on infested soil, it was possible to select the required type carrying disease resistance. A number of resistant strains, especially of the canning types, are now on the market. The indications are that resistant strains of the choice market-garden varieties will be available within the next few years.

TABLE 1.—*Some of the common varieties of peas grouped according to commercial use and season, and graded with respect to their relative resistance to Fusarium wilt*

Commercial use, season, and variety	Degree of resistance	Commercial use, season, and variety	Degree of resistance
Market-garden varieties:		Canning varieties:	
Early:		Early:	
Alaska	[1] 0–100	Alaska	0–100
American Wonder	0	Early Canner	0
Bliss Everbearing	100	Peerless	100
Claudit	0	Surprise	0
Duke Delight	0	Wisconsin Early Sweet	100
Extra Early	0–100	Midseason:	
First and Best	0–100	Abundance	0–100
Gradus	0–50	Advancer (Perfection)	0
Hundredfold	0	Ashford	0
Little Gem	0	Bruce	100
Little Marvel	0	Badger	0
Peter Pan	0	Canners Gem	0
Pioneer	0	Green Admiral	100
Premium Gem	0	Green Giant	100
Thomas Laxton	0	Horal	100
World Record	0–100	Horsford	0
Medium early:		Perfection (Advancer)	0
Laxtonian (Blue Bantam)	0	Prince of Wales	100
Laxton Progress	0	Resistant Perfection	100
Nott Excelsior	0	Rogers K	100
Sutton Excelsior	0–100	Senator	100
Midseason:		Short Admiral	0
Alderman	100	Yellow Admiral	100
Associated 40 or Dwarf Alderman	100	Field varieties:	
Daisy or Dwarf Telephone	0–100	Early:	
Morse No. 200	0	Alaska	0–100
Onward	0–100	Extra Early	0–100
Rogers No. 93 or Icer	100	First and Best	0–100
Stratagem (Potlatch)	0–100	Midseason:	
Stridsh	100	Austrian Winter	0–10
Tall Telephone	90–100	Bluebell (Blue Prussian)	100
		Capucijner	25–100
		Harrison Glory	100
		Maple	0
		White Australian	100
		White Canadian	0–100

[1] The figures 0–100, for example, indicate that some strains of the variety are 100 percent susceptible; others are 100 percent resistant, and still others are intermediate between 0 and 100.

Table 1 contains a list of a number of common varieties of peas and shows whether or not they are resistant, partially resistant, or susceptible to the wilt disease. It is advisable to select some of these resistant varieties for planting on soils that are known to be infested with the wilt organism. Attention should be called to the fact that there are possibly available some resistant strains in practically all of the varieties marked 0–100 percent in table 1, if the grower insists

on being supplied with such stock. Investigations have shown that strains of peas that are resistant to *Fusarium* wilt in one locality are resistant to the same organism in any other infested locality, no matter how far removed. In the case of canning peas, it is not advisable to sow partially resistant peas on infested soil. Not all infected plants are killed before they produce seed. However, infected plants that survive usually mature earlier than noninfected plants and pass the canning stage before the bulk of the crop is ready to harvest. Many of these prematurely ripened peas reach the can and reduce the quality of the pack.

NEAR WILT

DESCRIPTION

There has come to notice in recent years a disease of peas called "near wilt." It somewhat resembles the *Fusarium* wilt and sometimes might be confused with it. Not much is known about the disease, but attention is called to it so that losses caused by it will not be attributed to the *Fusarium* wilt. The causal fungus enters the water canals of the taproot and stem, just as does the wilt fungus, and may cause the wilting and death of the plant. The near wilt may attack the plant at a later stage of growth, sometimes after the crop is nearly mature. For this reason the loss from near wilt is much less than that from wilt which usually enters the stems of very small plants and kills them while they are fairly young. The near wilt might be overlooked entirely, and the sickly appearance of the plants attributed to root rots, lack of soil fertility, or other causes. Near wilt differs from root rot and may be distinguished from it in at least two characteristics. Plants affected with root rot usually pull from the soil much easier than near-wilt or wilt plants. Near-wilt plants may not show any signs of decay of the root. If the taproot is split open with a sharp knife and the central core is colored a brick red, the presence of the near-wilt organism is to be suspected. Attention should be called to the fact that if wilt-resistant strains of peas should fail to yield a crop on certain fields, it is not necessarily because they are not wilt resistant, but may be because of the presence of the near-wilt or even root-rot organisms. Varieties of peas resistant to wilt are not necessarily, and probably are not, resistant to near wilt. There are, however, some indications that varieties may differ in their susceptibility to near wilt.

ROOT ROTS

DESCRIPTION

Root rots are caused by several different parasites that produce symptoms so much alike that it is not always easy by a casual examination to distinguish them. Inasmuch as the known control measures apply about equally well to all root rots, any attempt to separate them by descriptions that, in part at least, may apply to all the root rots would only tend to confuse the reader.

Root rots, as the name indicates, occur on the roots or on all the underground parts of the plants and sometimes a short distance above the surface of the soil and are the cause of much loss. Most of the lesions are grayish brown or almost black, but occasionally some are

reddish and form definite streaks on the taproot or on the stem near the soil line. Root decay often begins at the tips of the small feeding roots and progresses gradually upward to the main root. In other cases, all the roots are destroyed, leaving nothing, or only shreds, below the attachment of the seed (fig. 7). Sometimes, however, the main root is the first to be affected.

In the root rot caused by the parasite *Aphanomyces euteiches* Drechs. the initial infection may take place either through the small

FIGURE 7.—Root rot. The feeding roots below the attachment of the seed are sometimes entirely rotted away. Similar injuries may be caused by several different organisms.

feeding roots or directly on the taproot. The final result is that the surface becomes more or less soft and slimy, and dark gray or brownish black in color. The slimy condition of the surface is influenced somewhat by the amount of moisture in the soil. In typical examples of root rot caused by this parasite, the outer portion of the taproot can be slipped readily from the central cylinder, which may often become somewhat water-soaked and soft. The decay may extend a short distance above the surface of the soil.

The root rot described above should not be confused with another very wide-spread root rot caused by the parasite *Fusarium martii* var. *pisi*. This fungus usually attacks the lower part of the stem in the

FIGURE 8.—Root rot. The darkened area of the upper part of the root and stem is typical of a root rot that causes decay of the stem both above and below the attachment of the seed. In later stages the plant may turn yellow and eventually die.

region of the attachment of the seed (fig. 8), and grows in both directions but more conspicuously up the stem, turning the infected region a dark brown to a brick red. The same parasite may be found

on the feeding roots, but it is found less commonly there than on the main root. This root rot may be identified with more certainty by the deep-red discoloration it causes to the central cylinder. By splitting open the stem at, or just above, the place where the seed is attached, the red coloring caused by the presence of the fungus may be seen to extend a little distance upward. Symptoms of other root rots might be described, but it would not be possible to give sufficient detail so that they could be distinguished from root troubles caused by other parasites. In advanced stages, the symptoms for all the troubles are very much alike. In fact, the root troubles of a single plant are not always caused by one parasite only. Several may be damaging the roots at the same time.

No particular skill is required to recognize root rot. Any observant farmer can recognize root trouble if he will take the pains to examine the roots. It makes very little difference what organism or group of organisms cause them; in fact, those who have been long engaged in the study of root rots are frequently unable to identify the different ones without a laboratory study. If the plants in the field are stunted, the leaves pale yellow, or exhibit an unhealthy appearance in other ways, it is a good plan to dig up some of the plants, carefully wash off the soil, and examine the roots for decay. They may be found wherever peas are grown, but the losses may sometimes be very small. Taking the country as a whole, it is believed that more loss is caused by root rots than by any other disease, and possibly more than by all other diseases combined. Root rots and wilt frequently occur together in the same fields; in that case it is difficult to determine which causes the greater loss.

Root rots may begin when the plant is in the seedling stage or, in fact, before it comes through the ground. Death of the plant soon follows such early infections.

CAUSE

Several organisms are known to cause root rots, and it is not unlikely that others that are not suspected, or that are little known, may be as responsible as those mentioned below. Those fungi generally associated with root decay are known by the following names: *Fusarium martii* App. and Woll. var. *pisi* Jones, *Aphanomyces euteiches* Drechs., *Corticium vagum* Berk and Curt., *Pythium ultimum* Trow., *Ascochyta pinodella* L. K. Jones, *Mycosphaerella pinodes* Berk. and Blox., *Sclerotinia sclerotiorum* (Lib.) Mass., *Thielavia basicola* (Berk. and Br.) Zopf, and *Sclerotium rolfsii* Sacc. The last-named organism requires especial mention, because it is restricted mostly to the Southern States. Several of these organisms cause root rots of crops other than peas, and probably all of them can live indefinitely in the soil independently of any of our cultivated crops.

CONTROL

The root rots of peas, like those of many other crops, are hard to control. As they are caused by organisms that live indefinitely in the soil, there is no practical way to eradicate them. Crop rotation is recommended as a good practice, but it is of no particular value in controlling pea diseases except in the case of those organisms that attack only peas. Most of the fungi are about as parasitic on the other crops that might be grown in the rotation as on peas.

Root rots are usually more severe during seasons of heavy rainfall than during dry years, and on low-lying fields that are poorly drained than on well-drained fields. Excessive soil moisture, regardless of the location of the field, favors the root-rot diseases. Where root rots have been troublesome, it is advisable to select well-drained fields and to prepare the soil thoroughly before planting. Plants that start growth poorly, as they do on impoverished soils, are much more subject to attack of root rots than plants on rich soils where a good vigorous growth is maintained from the very beginning. This naturally suggests that a fertilizer of the proper proportion of ingredients should be added to the soil where needed. The grower should provide conditions that will start the plants off well, and should keep them growing vigorously by selecting well-drained soils, by careful preparation of the soil, and by the application of the proper amount of fertilizer. At least a fair crop often can be grown in spite of root rots.

ROOT KNOT

DESCRIPTION

Root knot, largely confined to the light sandy soils of the South and to similar regions in California, is characterized by enlarged, irregularly shaped, deformed, fleshy galls (fig. 9) distributed on the root system. If the galls are broken open, pearl-white bodies about the size of a pinhead may often be seen. These are the female worms that cause the galls.

The root-knot galls may sometimes be confused with the nodules that normally develop on the roots of garden and field peas, beans, and other legumes. A careful comparison shows the two to be quite different. The nodules are usually smaller than the root-knot galls, more nearly round, and are attached somewhat loosely to the roots, whereas the root-knot galls are enlargements of the roots themselves. The bacteria that form the nodules change the nitrogen of the air into forms that are of some benefit to the plant and that are later changed into nitrates in the soil and thus become available to subsequent crops. Plants bearing nodules generally grow well and look healthy, while those with root knot are usually stunted, yellow, sickly looking, and may even be killed by the disease.

CAUSE

Root knot is caused by a parasitic eelworm, or nematode (*Heterodera marioni* (Cornu) Goodey) so small as to be almost invisible to the naked eye. It enters the roots and causes them to form irregular swellings or galls characteristic of the disease. It retards the growth, reduces the yield, and often kills the plants. To a considerable extent, these galls cut off the transport of food material from the roots to the rest of the plant. These little eelworms travel very slowly in the soil, probably not more than 1 to 2 yards in a year and they overwinter in the soil.

CONTROL

The eelworms, or nemas as they are generally called, are parasitic on a large number of cultivated plants and on many weeds. However, a number of crops are practically immune to their attack. Among the latter may be mentioned the Iron, Brabham, and Victor

cowpeas; the Laredo soybean, velvetbeans, corn, barley, rye, redtop, sorghum, timothy, wheat, and winter oats.

The most satisfactory method of controlling the disease is to practice rotation with immune crops for 3 or more years, in order to starve out

FIGURE 9.—Root knot, caused by a small parasitic eelworm or nematode that invades the roots. The galls may form at any place on the roots.

the nemas. Clean cultivation should be practiced to prevent the growth of susceptible weeds on which the nemas could feed. The nemas may be transported from one field to another or over long distances in the tubers, bulbs, or roots of growing plants, by implements

and drainage water, by farm animals allowed to roam from one field to another, and probably by other means. Distribution of the nemas by any of these means should be prevented as far as possible.

SEPTORIA BLIGHT

Septoria blight, caused by a fungous parasite (*Septoria pisi* West.), is one of the less important diseases of peas, and for that reason a somewhat brief discussion will suffice. It occurs mostly in the Northern States and develops best under cool, wet weather conditions. The *Septoria* blight is sometimes confused with the *Ascochyta* blight, but when the two diseases are carefully compared they may be easily distinguished. The spots caused by *Septoria* are somewhat indistinct, while those caused by *Ascochyta* are distinct. The *Ascochyta* blight is in part characterized by lesions with ashen-gray centers. With the *Septoria* fungus, however, the infection begins at the edge of the leaf, causing yellowish indefinite areas which gradually darken and enlarge until the entire leaflet is invaded (fig. 10). From the leaflets, the causal fungus spreads to the nodes, which are likewise yellowed and often shrunken. In the lesions, on the leaves, and especially on the nodes and lower part of the stem, pycnidia, or spore receptacles, more or less indefinitely arranged, are developed. Numerous spores are formed in the pycnidia. The spores emerge from them and are carried by the wind, on the bodies of insects, or by other agents to other plants, where a new infection takes place. By these means, an entire field may become infected within the period of a couple of weeks. If infection takes place when the plants are young, that is 3 to 8 inches high, their death is likely to result before a crop is produced. If, on the other hand, no infection occurs until the plants are nearly mature, a partial crop, at least, can be expected.

Septoria blight occurs in epidemic form with such infrequency that no control measures have been worked out, and only occasionally is there any need to apply them. Until more is known about this disease, little can be offered in the way of control. The methods suggested for the control of *Ascochyta* blight would probably be equally effective in reducing losses from *Septoria*.

POWDERY MILDEW

Powdery mildew of peas is caused by a fungous parasite (*Erysiphe polygoni* DC.). This same fungus occurs on beans and on a number of related legumes. The organism causing the powdery mildew of peas is probably as widely distributed as the crop. Like the powdery mildews of some of the other crops, it develops most abundantly under cool conditions, and consequently it is more prevalent on fall crops or on crops that are matured in the late summer, and where the nights are cool. It is characterized by the formation of a white powdery dustlike coating on the surface of the leaves and less frequently on the petioles of the leaves, stems, and pods. The leaves are yellowed, dwarfed, and sometimes considerably malformed. Only in extreme cases, however, are the vines killed. In severe cases of the disease, the powdery-mildew fungus causes small brown spots (fig. 11) or streaks on the pods. Damaged pods are not marketable although the food value of the peas is not affected.

The powdery mildew causes considerable damage in some sections of the country when conditions are favorable for the growth of the causal fungus. In the pea-growing sections of the States along the Pacific coast, and occasionally in other States, the application of control measures is required every year to produce a crop. Two different fungicides have been recommended, but only one is used to any extent on a commercial scale. In recent years, dusting the plants with

FIGURE 10.—*Septoria* blight on the pods, stems, and leaves. The round, black, slightly raised, small domelike pimples are the receptacles in which the fruiting bodies (spores) of the parasite are enclosed. When the spores escape from the receptacle they may be carried to other pods, stems, or leaves and start new infections.

sulphur has given good results. The first dusting should be done as soon as there is any sign of the disease, and another about a week or 10 days later. Sometimes as many as 6 or 7 applications are necessary to insure a crop. The application of a 4–4–50 bordeaux mixture has been used, but better results have been obtained with sulphur dust, which should be used whenever control measures must be applied. Crop rotation and the turning under of the refuse left in the field

immediately after harvest by deep plowing are practices that should be followed by the growers.

ANTHRACNOSE

The anthracnose of peas is caused by a fungus parasite (*Colletotrichum pisi* Pat.). It has been reported from several States, but in only one, Wisconsin, where it was severe for 1 or 2 years, has it been regarded as of any importance. On all parts of the plant above ground, the fungus causing anthracnose produces lesions that resemble those caused by the *Ascochyta* blight fungus. On the leaves it causes irregularly shaped, gray to brown spots; on the pods the spots are more nearly circular. The spots on the stem are elongated and ashen-colored.

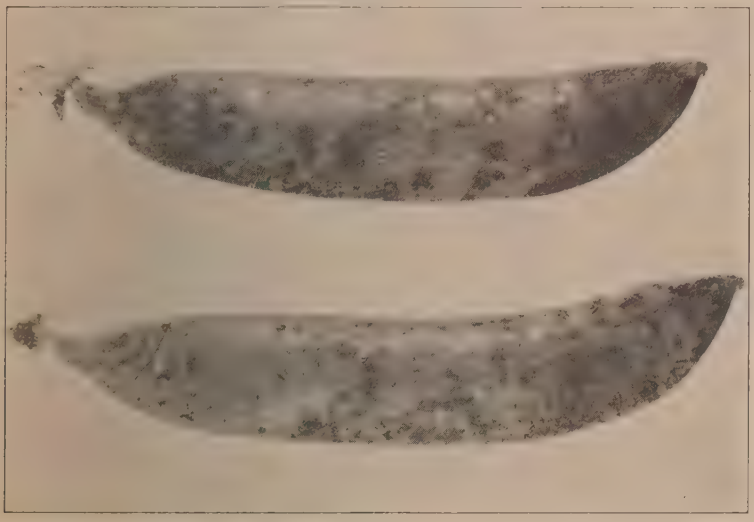

FIGURE 11.—Powdery mildew on pods, showing irregularly shaped brown spots and blotches. Pod infection reduces the market value. The symptoms may appear also on the leaves and stems as a white powdery talclike substance scattered over the surface.

The spores, or seedlike bodies, are formed in large numbers in the lesions and may be distributed by rain or carried from one plant to another on the bodies of insects, on farm implements, and possibly by the wind and by various other means. In the presence of moisture, the spores quickly germinate and cause new infections. It is not definitely known how the organism survives the winter, but it is suspected that it may live from one season to the next in and on the seed and in the refuse left in the field from a previous crop.

No control measures have been worked out. It is probable that crop rotation, the plowing-under of the refuse left on the field, and the use of disease-free seed will help to hold the disease in check.

DOWNY MILDEW

Downy mildew is caused by a fungus (*Peronospora viciae* Berk.). This disease, although widely distributed, is not considered of economic importance except in the States of Washington and Cali-

fornia, and possibly in 1 or 2 other Western States. It causes a water-soaked condition of the affected parts and is further characterized by the white, downy or cottony growth (fig. 12) that may be found on any of the aboveground parts of the plants. The fungus also

FIGURE 12.—Downy mildew. This disease sometimes grows through the pods and forms a mass of white mycelium within.

attacks different species of vetch, and from them it may be carried to the pea.

Control measures are not always required. When the disease is severe, it may be held in check by 2 or 3 applications of a 4–4–50 bordeaux mixture. The first application should be made as soon as

there is any evidence of the fungus on any part of the plant. The applications should follow each other at intervals of 7 to 10 days.

MOSAIC

DESCRIPTION

Pea mosaic has been known for a number of years, but it has never become so widespread or destructive as bean mosaic. It probably never kills the plant but produces very characteristic symptoms.

Pea mosaic, unlike most of the mosaics of other plants, causes very little stunting of the host, since infection usually takes place rather late in the life of the plant. Leaves affected with mosaic show the intermixing of light and dark areas (fig. 13) characteristic of mosaics in general. The mottled areas are irregular in outline and may follow the small veinlets. In later stages these green areas enlarge and become yellowish green, giving the leaf a netted appearance. In general, the leaves of infected plants may be somewhat smaller than those of healthy plants, and frequently there is a slight curling of the edges. In severe cases of the disease the leaves may become somewhat curled, twisted, and dwarfed. The symptoms of the disease cannot be recognized on the stems or seeds, but the pods frequently are distorted, malformed, and dwarfed.

CAUSE

Pea mosaic is caused by a virus, the nature of which is little known. The spread of the disease is not clearly understood, but occasionally it can be transmitted by rubbing diseased leaves against the leaves of healthy plants. The pea aphis is also believed to be responsible for much of the secondary spread of the disease in the field. It has not been definitely proved that the disease is seed-borne, but preliminary evidence indicates that it may be carried in the seed in very small percentages. The disease as yet is not of great economic importance in the United States, but in certain pea-growing localities it causes some damage in reducing the yield and quality of the product.

CONTROL

There are no effective control measures known to combat the disease. Since the pea aphis is responsible for some of the spread in the field, the control of these insects may reduce the amount of spread. It is advisable in cases of slight infection to rogue out all infected plants as soon as they are seen, thereby reducing the possibility of secondary spread.

The relative resistance and susceptibility of the different pea varieties are not known. The market-garden types seem to be more susceptible than the canning or field types.

FIGURE 13.—Pea mosaic. Note the streaks of yellow and green, causing a mottled appearance of the infected leaves.

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